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Analysis on Steel Bridge Pavement Structure Performance

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Abstract

Combined with road performance analysis of three pavement structure, including double layer SMA, GA+SMA, and EA+SMA. An application condition for pavement structure was put forward. The results show that EA-10 + SMA-13 is recommended for very heavy traffic owing to the anti-rutting performance and durability of EA; GA-10+ SMA-13 is to consider adopting as the heavy traffic; SMA-10+SMA-13 is recommended under light traffic conditions.

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Keywords: Bridge deck pavement; Road performance; Structure combination; Applicable condition

1. Introduction

The quality of bridge deck pavement impacts driving comfort and safety. After passing long-term research and test, lots of steel bridge pavement structure have built successfully all over the world, but the diseases of pavement structure is still a matter of debate and has not be solved. Bridge deck pavement act on the orthotropic steel deck plate directly, the status of stress and strain are both complex. Pavement structure is susceptible to damage under external environment and overload etc. Almost all of the steel bridge deck pavement appeared the disease of translation and rut diseases which is not solved completely in the world at present. In light of this problem, in addition to introduce the foreign advanced design technology, research and develop excellent new materials had to analyze performance of pavement structure.

2. Materials and Structures

In recent years, bridge deck pavement has been formed a variety of pavement structure types gradually with

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the development of the new materials，including three kinds of pavement materials (SMA, EA, GA) and two kinds of pavement structures (single-layer pavement and double--layer pavement) .

Single-layer pavement often uses gussasphalt which is a dense graded mixture. Gussasphalt with high performance polymer modified bitumen has a longer fatigue life and a lower breaking temperature; they can be used in the future surfaces for steel bridge decks in Germany and Japan. When paving at steel deck, attentions should be given to its stability at high temperature because it prone to form rutting diseases on the high temperature environment. The relevant studies have shown that single-layer pavement does not apply to our country due to the climate conditions and traffic conditions, for example, Jiangyin Yangtze River Bridge that adopted single layer GA pavement structure had serious early destruction: transverse and longitudinal crack, block crack, pushing, slip and rutting, etc.

At present, the steel bridge deck pavements are mainly composed of double-layer structure combinations which have different functions of pavement layers. As shown in Table 1.

Table 1. Function of pavement layers

Layer	Function
Upper layer	As a function of surface layer, the upper storey must be has good road performance which need to be able to meet the cracking resistance and seepage resistance.
Lower layer	Lower storey should has a good function of water-resistance and resistance load

Above all, three kinds of pavement structures, including SMA-10+ SMA-13, GA-10+ SMA-13 and EA-10+ SMA-13 are selected to study the performance in this paper.

3. Pavement Performance

3.1. High temperature rutting tests

In this section, high temperature (60℃) rutting tests have been made in the test instrument for three kinds of pavement structures, including SMA-10+ SMA-13, GA-10+ SMA-13 and EA-10+ SMA-13. The sequence of sample shaping as follows: steel plate processing - anticorrosive layer - epoxy bonding layer ($0.8 \sim 1.2\ kg/m^2$) - pavement lower layer (*40 mm*) - SBR adhesive layer ($0.3 \sim 0.5\ kg/m^2$) - pavement upper layer (*40 mm*). The test results are shown in Table 2.

Table 2. Result of rutting test（60℃）

Pavement scheme	Dynamic frequency（*time/mm*）	Rut depth（*mm*）
SMA-10+ SMA-13	6130	0.72
GA-10+ SMA-13	4059	1.13
EA-10+ SMA-13	>10000	0.28

As seen in Table 2, the performance of pavement to resist high temperature rutting as follows: EA - 10 + SMA - 13 > SMA - 10 + SMA - 13 > GA - 10 + SMA - 13. Dynamic stability is all more than 4000 times/mm, rutting depth is all less than 1.5 mm, which shows that three kinds of pavement structure combination schemes have a good high temperature performance.

3.2. Fatigue test

Fatigue experiments is chosen to test the fatigue performance of pavement structures, test parameters are shown in Table 3, and the test results are shown in Table4.

Table 3. Fatigue test parameters

Loading frequency	Test temperature	Loading waveform	Steel plate thickness	Pavement layer thickness
10Hz	15℃	Half string wave	18mm	80mm

Table 4. Result of fatigue test

Pavement scheme / Horizontal strain	SMA-10+ SMA-13	GA-10+ SMA-13	EA-10+ SMA-13
	fatigue cycle number(times)		
500	847060	934700	1003806
750	357610	392560	503510
1000	265050	327350	389120
1250	219960	287020	334678
1500	19430	24790	37492

As seen in Table 3, the fatigue performance of pavements as follows: EA - 10 + SMA - 13 > GA - 10 + SMA - 13>SMA - 10 + SMA - 13. The fatigue life is falling with the increase of the strain level, and the change trend of fatigue life of pavement schemes are consistent.

3.3. Other road performances

Paper analyzes and compares other road performances of pavement structures by reviewing a vast amount of literatures，the result as shown in Table 5.

Table 5. Result of analysis and comparison

Pavement performance	SMA-10+SMA-13	GA-10+SMA-13	EA-10+ SMA-13
Surface characteristic	coarse	coarse	coarse
Skid resistance	good	good	good
Traffic noise	light	light	light
Crack resistance	bad	medium	medium
Resistance water damage （%）	3.0~4.0	1~1.5	2~4
Ageing resistance	medium	perfect	good
Durability	bad	good	good

4. Application Condition

Suggestions that choose different pavement structure combinations according to the load conditions by analyzing the road performance above. As shown in Table 6.

Table 6. Application conditions of pavement structure

Traffic level	Light traffic	medium traffic	heavy traffic	very heavy traffic
BZZ - 100 cumulative standard axle Ne time (time/lane)	$< 3\times10^6$	$3\times106\sim1.2\times10^7$	$1.2\times107\sim2.5\times10^7$	$> 2.5\times10^7$
all kinds of truck traffic (a/d * lane)	< 600	600～1500	1500～3000	> 3000
Pavement upper layer	SMA-13	SMA-13	SMA-13	SMA-13
Pavement lower layer	SMA-10	SMA-10 EA-10 GA-10	EA-10 GA-10	EA-10

EA-10 + SMA-13 is recommended for very heavy traffic owing to the anti-rutting performance and durability of EA; GA-10+ SMA-13 has the advantage of anti-rutting performance, although GA lack high temperature stability and easy forming rutting. This pavement structure to consider adopting as the heavy traffic; GA and EA are discouraged under light traffic conditions by the reason that GA and EA is in great difficulty with high cost. SMA-10+SMA-13 is recommended under light traffic conditions. The performance tests also indicated this point.

Conclusions

1) Although EA-10 + SMA-13 has the advantage of anti-rutting performance and durability and low-temperature cracking resistance, it is not widely used as a result of the disadvantage such as high cost, hard to be constructed, long-time maintenance.

2) GA-10 + SMA-13 has the advantage such as waterproof, anti-corrosion and ageing resistance owing to the low porosity of GA. Meanwhile, it has superior performance of anti-rutting, anti-fatigue and anti-cracking.

3) SMA-10+ SMA-13 has the excellence credible technology, agility economy and advantage construction, which is very suitable for the steel bridge pavement.

4) EA-10 + SMA-13 is recommended for very heavy traffic owing to the anti-rutting performance and durability of EA; GA-10+ SMA-13 is to consider adopting as the heavy traffic; SMA-10+SMA-13 is recommended under light traffic conditions.

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